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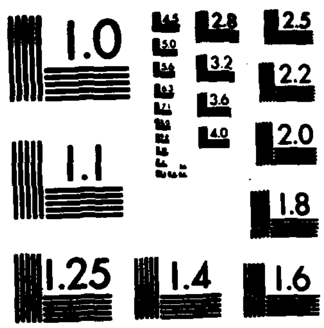

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NPRDC Special Report 83-32 May 1983

FIELD EVALUATION OF ENRICHED HYBRID JOB PERFORMANCE AIDS

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Twenty Navy technicians participated in a field evaluation of the effectiveness of enriched hybrid job performance aids (EHJPAs) for troubleshooting the AN/AWG-10 airborne weapon control system. In a between-subjects design, each group used one of four troubleshooting formats on two troubleshooting tasks: (1) deductive information only (DED), (2) hybrid aid without any enrichment (UN), (3) an enriched hybrid (TS/IC), and (4) another enriched hybrid with technical data references (SS/BRC). Performance across tasks, as well as performance on a pre- and posttask using the DED format were

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compared. Using the TS/IC format, technicians solved the two tasks 58 percent faster than did the technicians using DED. Improvement from the pre- to posttasks for the TS/IC group was 65.6 percent, compared to 31.9 percent for the DED group. One hundred percent of all hybrid groups solved the posttask, compared to the 83 percent of the DED group. One hundred percent of all hybrid groups said the hybrid aids were easier to use and understand than existing technical material. In a test on system knowledge, the SS/BRC group was superior when compared to the other groups. Combining the results with the user preference for the SS/BRC format, it was concluded that the SS/BRC was the most effective EHJPA.

FOREWORD

This research and development was guided by Navy Decision Coordinating Paper (NDCP) Z0828-PN (Enlisted Personnel Individualized Career System (EPICS) (formerly entitled Performance Aids Test and Evaluation)), under the sponsorship of the Deputy Chief of Naval Operations for Manpower, Personnel, and Training (OP-01). The objectives of the NDCP are to define the state of the art in job performance aid (JPA) technology, develop a conceptual model for an integrated JPA-based personnel system including cost benefits and trade-off analysis, test the JPA concept, and quantify performance increments and costs benefits obtainable for various applications.

This report is the seventh in a series of NAVPERSRANDCEN reports dealing with JPA technology development. Previous reports described the status of JPA technology (TR 77-33), a personnel system concept emphasizing the use of JPAs (TN 78-6), JPA research and state of the art (TR 78-26), a JPA selection algorithm for an integrated personnel system (TN 79-1), development of hybrid and enriched hybrid JPAs (TR 79-25), and the development and testing of a troubleshooting aid for digital systems. The purpose of the present effort was to evaluate hybrid JPAs in an operational environment. Results are intended for the JPA and technical documentation community.

Appreciation is expressed to the personnel of the AN/AWG-10 Missile Control System School at NAS Oceana, Virginia for their assistance in conducting this study.

JAMES F. KELLY, JR.
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SUMMARY

Problem

Prior research in job performance aid (JPA) formats for troubleshooting has focused on the development of deductive JPAs for the fully trained and experienced technician and directive JPAs for the inexperienced technician. Neither format is satisfactory for an individual at an intermediate skill level.

The hybrid JPA presents troubleshooting information in both directive and deductive formats. The intended purpose of the hybrid JPA is to allow an inexperienced technician to troubleshoot a given set of symptoms correctly using the directive part of the hybrid. At the same time, by examining the deductive part of the hybrid, the apprentice technician can begin to incorporate standard technical data, such as functional flow diagrams or schematics, in his troubleshooting approach. Over time, the technician should gradually transition from the directive to the deductive element and begin to develop troubleshooting strategies.

In an earlier effort, the potential of "enriching" the hybrid was evaluated. Enrichment is a method of adding job relevant information that should facilitate the transition between directive and deductive formats by providing the technician with a functional understanding of the system. Various conceptual formats for the enriched hybrid JPA (EHJPA) were defined, but none were evaluated in an operational setting to determine whether a technician could transition from the directive to the deductive or if the enrichment information contained in the EHJPA increased the technician's functional understanding of the system.

In addition to using the EHJPA to facilitate an inexperienced technician's troubleshooting abilities, the deductive element of the EHJPA can be used by the more experienced technicians for troubleshooting. In the instructional setting, the EHJPA would allow instructors to point out to the students the relationship between the directive elements and the development of a deductive troubleshooting strategy.

Purpose

The purpose of this study was to develop and evaluate alternative hybrid JPA formats to determine if (1) inexperienced technicians can transition to a deductive-only JPA after using a hybrid JPA to facilitate the formation of troubleshooting stragegies and (2) placement of additional information (enrichment) in a JPA is an effective technique for increasing technicians' system knowledge. The EHJPA is an integral component of the enlisted personnel individualized career system (EPICS). In EPICS, technicians need troubleshooting JPAs to supplement the formal training that is deferred and distributed over an individual's career.

Approach

Twenty Navy personnel served as subjects. They were classified according to training level (high and medium) and randomly assigned to four groups, according to the type of aid used: (1) the deductive (DED) JPA, (2) the unenriched (UN) HJPA, (3) the task-specific/internally cued (TS/IC) EHJPA, and (4) the system-specific/basic-reference-cued (SS/BRC) EHJPA. The two EHJPA formats differed in that the SS/BRC included references to technical manuals as well as information on the format.

All groups were tested on the AN/AWG-10 missile control system simulator. They were given a short introduction, a troubleshooting pretask using the DED format, a pretest on system knowledge (nomenclature and components), two troubleshooting tasks using their assigned JPA format, a troubleshooting posttask using the DED format, a posttest on system knowledge, and a questionnaire/interview on user acceptance. Subjects in the DED group were used as a control and compared to those in the hybrid groups as to fault-isolation time, solution rate, system knowledge, and user acceptance.

Results

1. All of the hybrid groups required less time on the troubleshooting posttask than did the DED group. However, only the TS/IC group completed the task significantly faster than did the DED group.

2. For the posttask, the solution rate for the hybrid groups was 100 percent, compared to 83 percent for the DED control group.

3. Between the pre- and posttests on system knowledge, the SS/BRC group improved by 38 percent on system nomenclature and by 47 percent on system components. There were no increases in system knowledge for the other groups.

4. All of the hybrid aid users rated their aid as easier to use and understand than technical manuals, compared to 67 and 57 percent of the DED users. In ranking JPAs, the SS/BRC was ranked first, followed by the TS/IC, the UN, and the DED.

Conclusions

The findings suggest that an effective EHJPA has a directive element that allows an inexperienced technician to troubleshoot accurately and a deductive element that allows him to comprehend the troubleshooting strategy embodied in the directive element. The addition of enrichment supplies the rationale for each step in the strategy. Over time, the technician can be expected to gain an understanding of the troubleshooting logic of the directive element and transition to using the deductive element alone. He will then be able to extend his troubleshooting strategies to more complex symptoms for which there are no aids and rely upon conventional functional flows and schematics to troubleshoot the problem.

Although the TS/IC group required less time to fault-isolate the final task than did the SS/BRC group, the results of both the system knowledge test and user acceptance questionnaire/interview suggest that the SS/BRC is the more effective EHJPA.

Recommendation

It is recommended that the SS/BRC format be developed for the EPICS technician, who will be required to provide troubleshooting support at the intermediate level.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Problem

Research in job performance aid (JPA) formats for troubleshooting can be divided into two general areas, directive (e.g., fully proceduralized JPAs) and deductive (e.g., functional schematics). Directive formats allow novice technicians to perform on the job without extensive training and experience, while deductive formats allow fully trained and experienced technicians to continue in a job without relying on memory alone. Neither format, however, is satisfactory for an individual at an intermediate level of skill.

The hybrid JPA presents troubleshooting information in both directive and deductive formats. The intended purpose of the hybrid JPA is to allow an inexperienced technician to troubleshoot a given set of symptoms correctly using the directive part of the hybrid. At the same time, by examining the deductive part of the hybrid, the apprentice technician can begin to incorporate standard technical data, such as functional flow diagrams or schematics, in his troubleshooting approach. Over time, the technician should gradually transition from the directive to the deductive element and begin to develop troubleshooting strategies.

In an earlier effort, the potential of "enriching" the hybrid was evaluated. Enrichment is a method of adding job-relevant information that should facilitate the transition between directive and deductive formats by providing the technician with a functional understanding of the system. Various conceptual formats for the enriched hybrid JPA (EHJPA) were defined, but none were evaluated in an operational setting to determine whether a technician could transition from the directive to the deductive or if the enrichment information contained in the EHJPA increased the technician's functional understanding of the system.

In addition to using the EHJPA to facilitate an inexperienced technician's troubleshooting abilities, the deductive element of the EHJPA can be used by the more experienced technicians for troubleshooting. In the instructional setting, the EHJPA would allow instructors to point out to the students the relationship between the directive elements and the development of a deductive troubleshooting strategy.

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Background

Enlisted Personnel Individualized Career System

Increasing training and personnel costs, a high attrition rate with its accompanying loss of the Navy's investment, a decreasing manpower pool, and the increase in technological complexity of systems have led the Navy to consider alternate career systems (Blanchard & Laabs, 1978). The objectives of one alternative, EPICS (Blanchard & Smillie, 1980), are to (1) get the individual on the job as quickly as possible, allowing him to contribute to ship's work with minimum initial investment in formal training, (2) ensure that the system provides the advancement of qualified, career-oriented personnel, (3) improve utilization of lesser-aptitude personnel, and (4) provide ultimately for the

development of a trained career force. These objectives are to be met through the use of JPAs, deferred formal training, transition adaptation training, and an individualized career advancement structure.

JPAs in EPICS

Goff, Schlesinger, and Parlog (1969) demonstrated that JPAs are an effective tool since they allow those individuals with little formal training, as well as those of lesser aptitude, to perform productive work. JPAs are useful within EPICS because training can be deferred until it has been determined that the individual has the ability and motivation to take advantage of a formal training program. In addition, deferment gives the Navy time to determine whether such a training investment would benefit the Navy itself.

Early in the EPICS career path, the technician performs calibration, remove and replace tasks, and preventive maintenance using fully proceduralized JPAs (FPJPAs). FPJPAs are comprehensive, self-contained, and require little decision-making by the technician. While these FPJPAs meet the needs of a novice troubleshooter by providing the necessary guidance, they are too detailed and somewhat demotivating for an experienced troubleshooter. As a technician progresses and becomes more knowledgeable about the system and more skillful in troubleshooting, a deductive aid (which allows him to exercise his judgment and apply his expertise) becomes more appropriate and useful. As the technician's needs change, so must the JPA.

Hybrid JPAs and Enrichment

The hybrid aid concept first emerged from a review of types of troubleshooting aids by Post and Price (1973), which concluded that one or the other of the terms "directive" or "deductive" could characterize all troubleshooting presentation techniques. They proposed that a single JPA in which the directive and deductive aid presentation formats appear side-by-side would facilitate the development of troubleshooting strategies by inexperienced technicians.

The enrichment concept was developed to offset negative aspects of JPAs. It had been found that, while FPJPAs could produce effective and efficient maintenance work, continued use of such aids may result in rote task performance, little learning, and job dissatisfaction (Johnson, Thomas, & Martin, 1977). Enrichment is a means of combining learning materials with the JPA to make work more rewarding and to promote on-the-job learning. Pulliam, Goett, and Smith (1979) suggested that introducing supplemental information to the JPA as it relates to the task at hand is an effective way to impart additional knowledge to the user.

Post and Smith (1979) developed several enriched and nonenriched hybrid aid forms and pilot tested them on untrained subjects for their ability to teach novice technicians to troubleshoot using only the deductive aid. In the test, subjects initially achieved a low solution rate using only the deductive aid. After several learning trials with the hybrid, there was a significant increase in performance when once again only the deductive aid was used.

APPROACH

Experimental JPA Formats

Four experimental JPA formats were tested: (1) the deductive (DED) JPA, (2) the unenriched (UN) HJPA, (3) the task-specific/internally-cued (TS/IC) EHJPA, and (4) the system-specific/basic reference-cued (SS/BRC) EHJPA. These formats are illustrated in Figures 1 through 4 and are described in the following paragraphs.

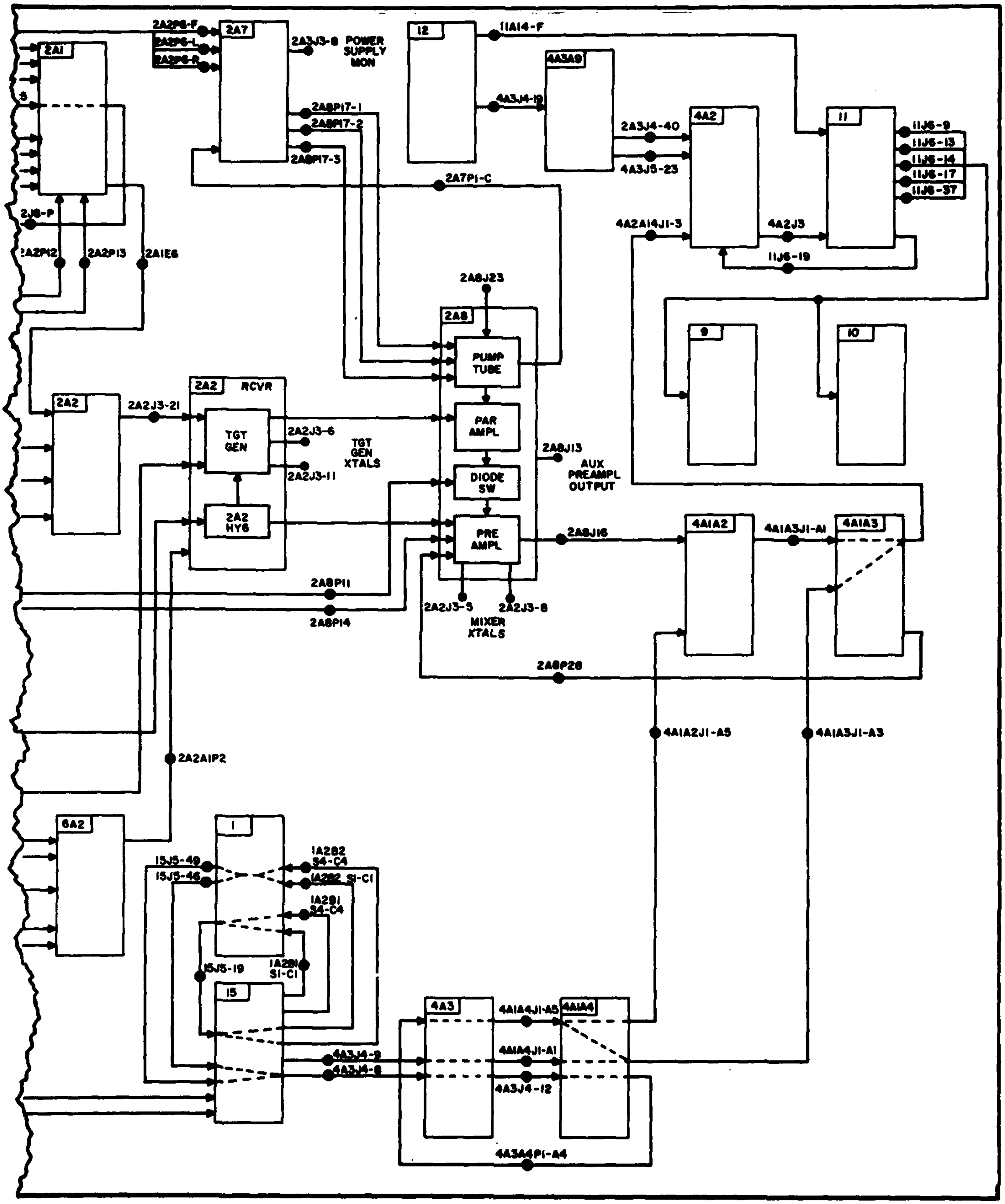
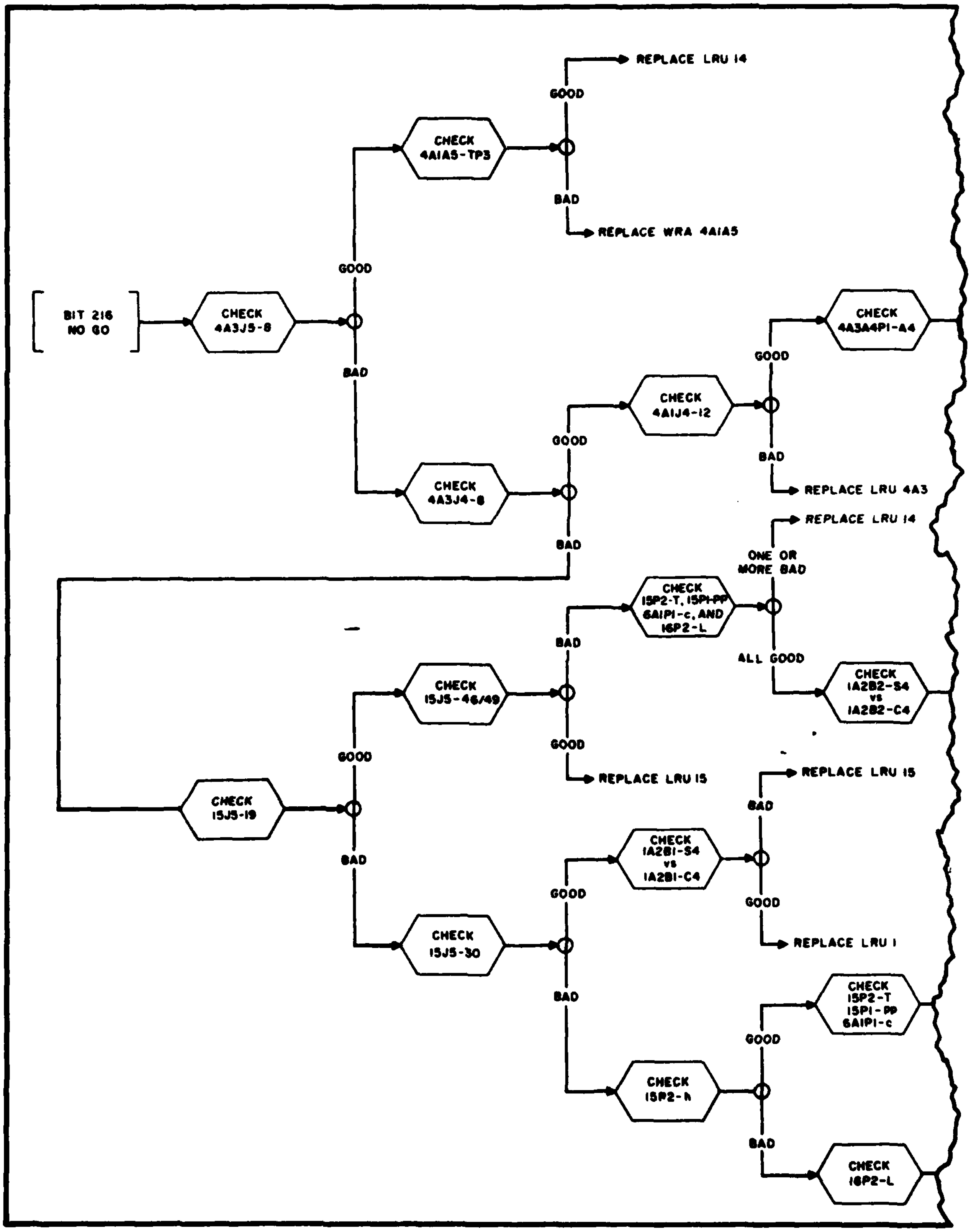
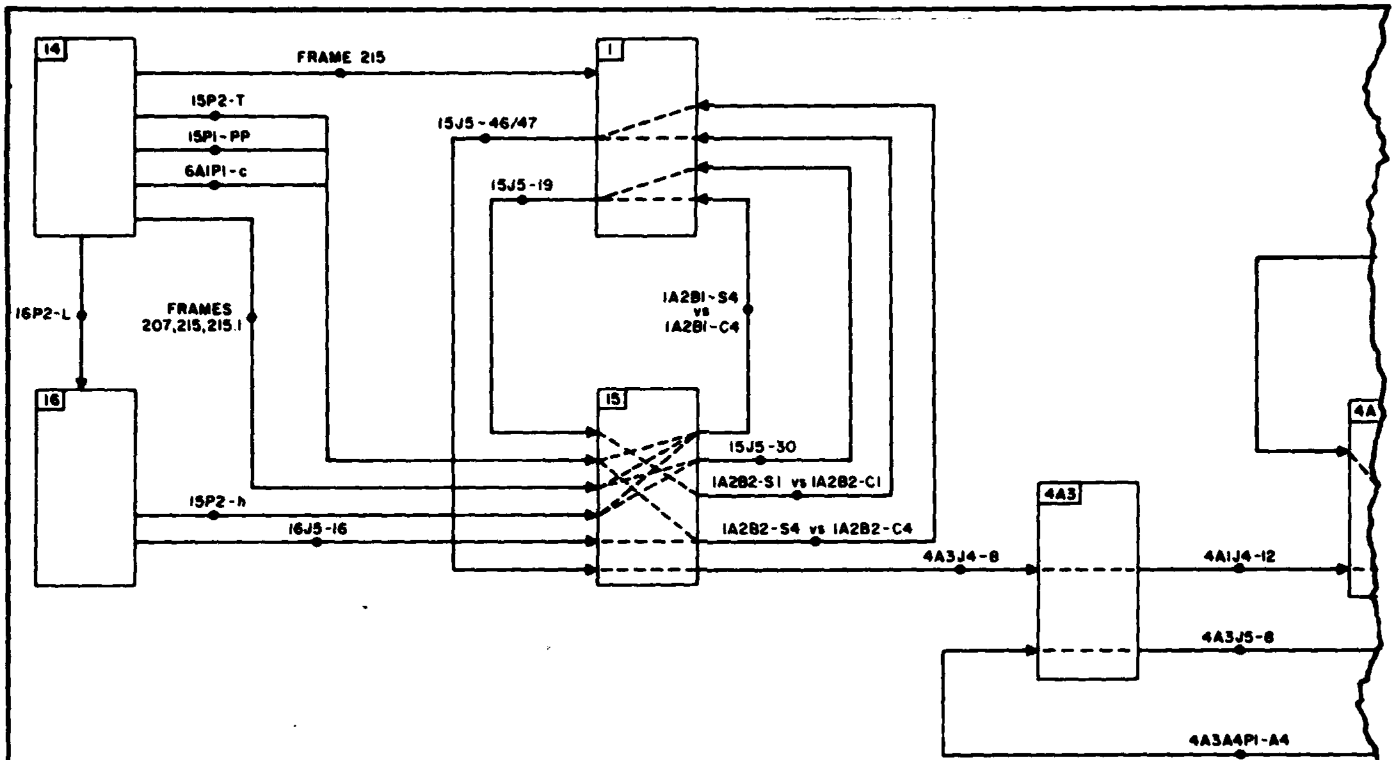


Figure 1. Illustration of a deductive (DED) job performance aid (JPA).



a. Directive element.

Figure 2. Illustration of an unenriched (UN) hybrid job performance aid (HJPA).

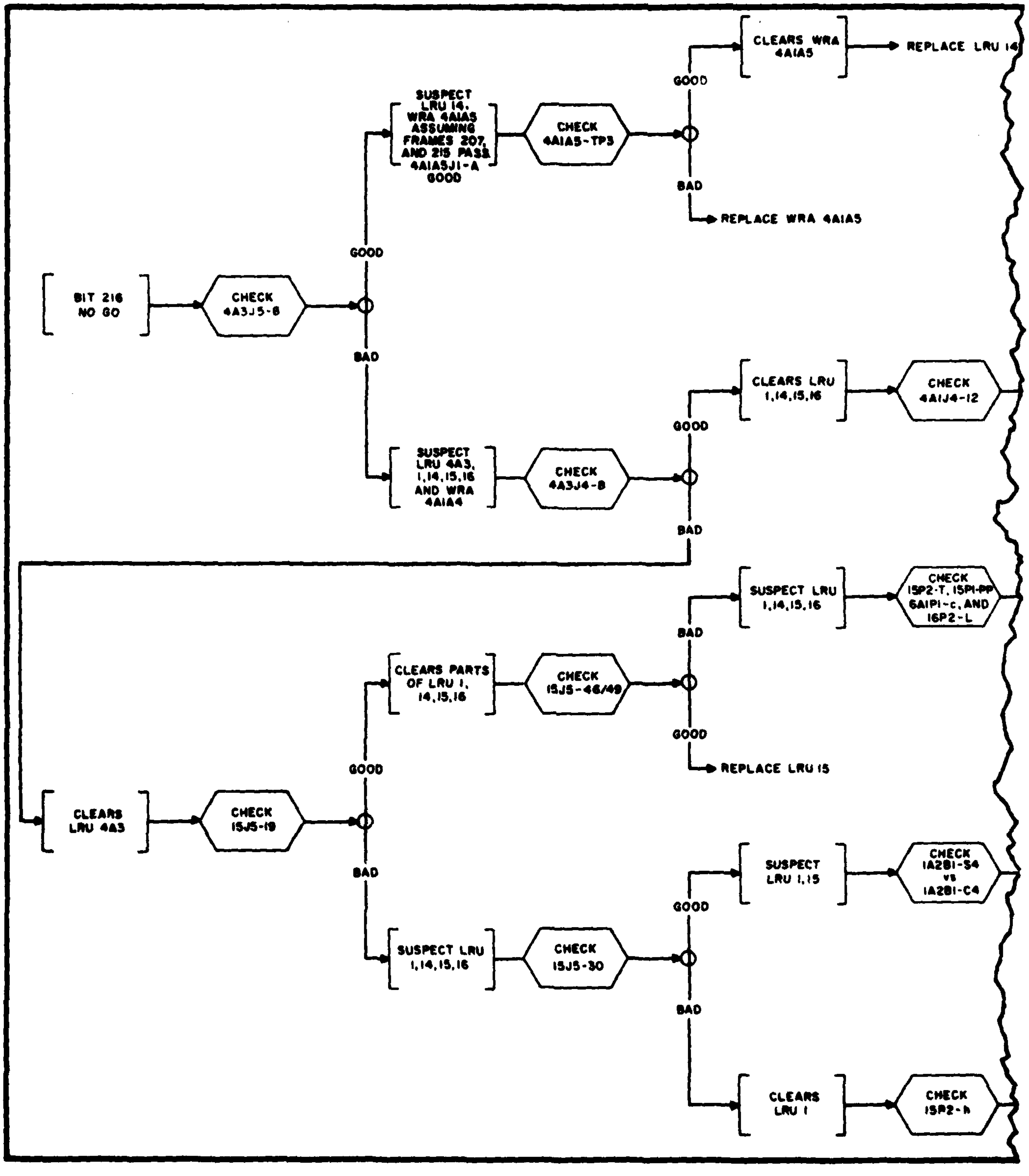


TEST SPECIFICATIONS		
TEST POINT	SIGNAL	VALUE
1A2B1-S4 vs 1A2B1-C4		DVM REQUIRED TEST PASSES IF ANY OF THE FOLLOWING IS TRUE: (1) C4 BETWEEN 9.5 AND 10.5 VAC (2) S4 < 10.5 VAC IF C4 10.5 VAC (3) S4 > 9.5 VAC IF C4 < 9.5 VAC
1A2B2-S1 vs 1A2B2-C1		DVM REQUIRED TEST PASSES IF ANY OF THE FOLLOWING IS TRUE: (1) C1 BETWEEN 8.3 AND 9.2 VAC (2) S1 < 9.2 VAC IF C1 > 9.2 VAC (3) S1 > 8.3 VAC IF C1 < 8.3 VAC
1A2B2-S4 vs 1A2B2-C4		DVM REQUIRED TEST PASSES IF ANY OF THE FOLLOWING IS TRUE: (1) C4 BETWEEN 1.4 AND 1.6 VAC (2) S4 > 1.4 VAC IF C4 < 1.4 VAC (3) S4 < 1.6 VAC IF C4 > 1.4 VAC
4A1A5-TP3	MBC LOCKUP	> +22V
4A1A5J1-A2	DOPPLER IF	800 MV P-P (OSCILLOSCOPE)
4A1J4-12	ADJUSTED MAIN BEAM CLUTTER	DVM REQUIRED -3.91 TO -4.11V
4A1P1-12	SIG SEL 2 (E2)	< +1

TEST POINT	SIGNAL	VALUE
4A1P1-13	SIG SEL 3 (E3)	< +1
4A1P1-14	SIG SEL 4 (E4)	> +22V
4A3A4P1-A4	2 ND LO CONTROL SIGNAL	EXTENDER REQUIRED DVM REQUIRED -5.29 TO -5.59V (NOTE 1)
4A3J4-8	PREDICTED MBC	DVM REQUIRED -3.9 TO -4.1V
4A3J5-8	2 ND LO	COUNTER REQUIRED 18.752925 TO 20.352925 MC
6A1P1-c	ANT. 30/30 (A8)	> +22V
14J7-10	MBC LOCKUP	< +22V
15J5-19	1A2B1-R3	DVM REQUIRED 8.55 TO 9.45V
15J5-30	1A2B1-S1	DVM REQUIRED < 0.5 VAC
15J5-46/49	1A2B2-R1/1A2B2-R4	DVM REQUIRED 8.30 TO 9.20 VAC
15P1-z, 15P2-T	ROLL 0, PITCH 30 (A10, A13)	> +22V
15P1-PP	WIND ZERO (A7)	> +22V
15P2-h	V_{ab}	10 VAC, 400 CPS
16J5-16	V_{ad}	5 VAC, 400 CPS
16P2-L	CMPTR TEST INPUT 5 (A1, A3)	> +22V

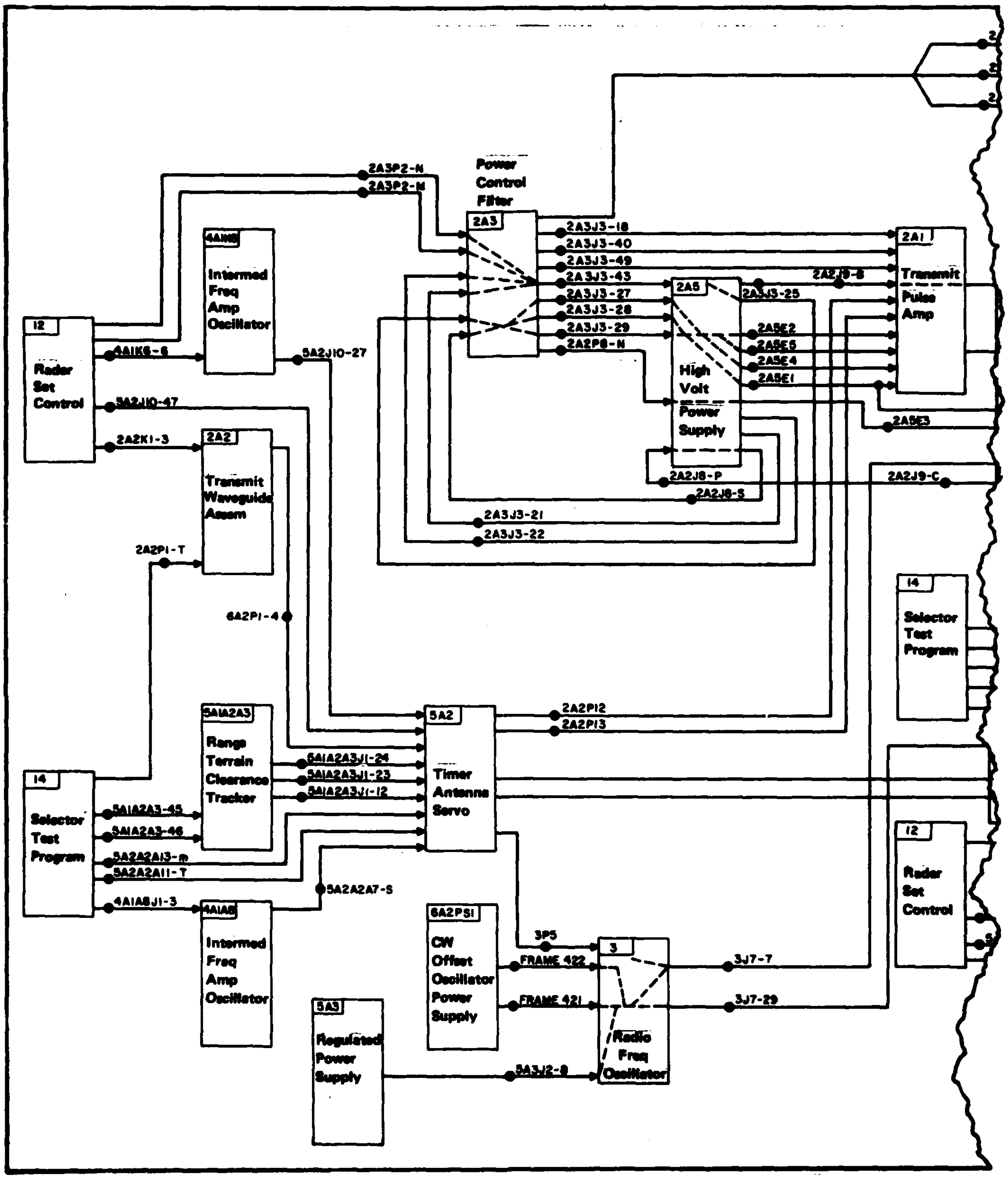
b. Deductive element.

Figure 2. (Continued.)



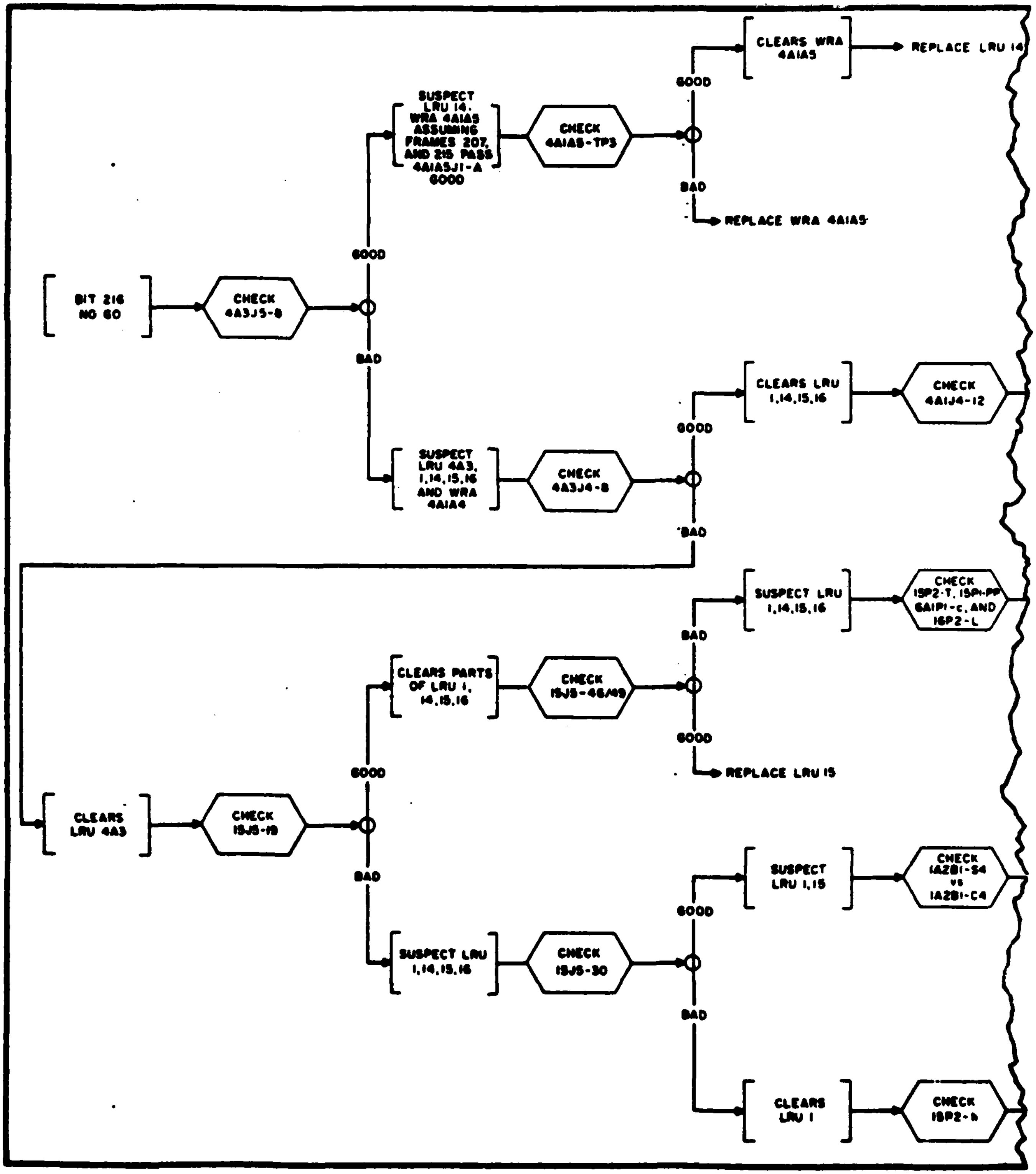
a. Directive element.

Figure 3. Illustration of a task-specific/internally-cued (TS/IC) enriched hybrid job performance aid (EHJPA).



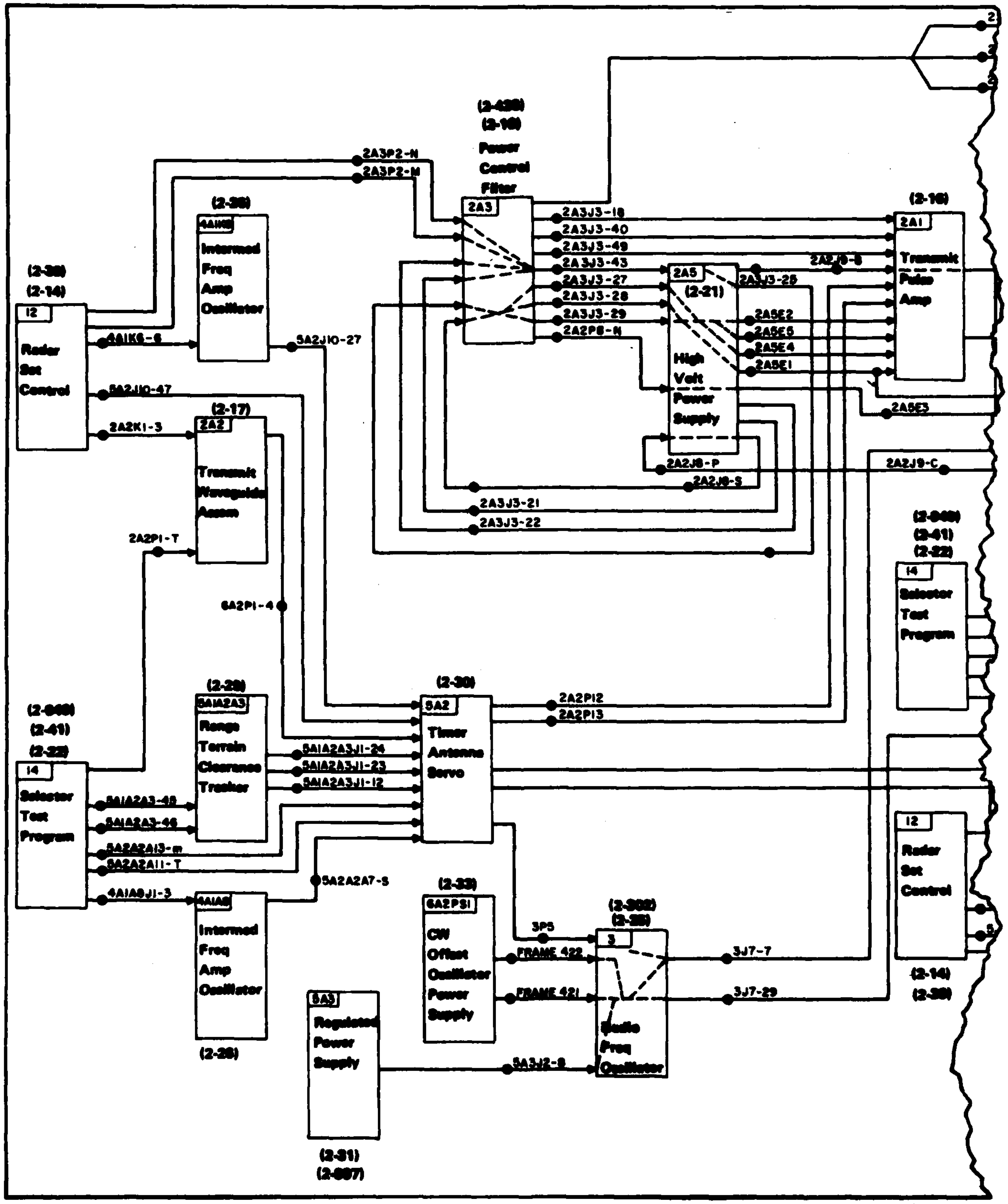
b. Deductive element.

Figure 3. (Continued.)



a. Directive element.

Figure 4. Illustration of a system-specific/basic-reference-cued (SS/BRC) enriched hybrid job performance aid (EHJPA).



b. Deductive element.

Figure 4. Continued.

Deductive (DED) JPA

Figure 1 shows a sample of a DED JPA in the form of a block diagram. Blocks represent line replaceable units (LRUs); lines and arrows, current flow; dashed lines, dependencies; and heavy dots, test points. The aid lists each test point and is accompanied by a table listing the test points, the signals, and the value of good signals.

The DED JPA does not direct the technicians as to what troubleshooting steps to perform. Rather, the user must be a decision maker and must "deduce" the most efficient order in which to test the test points. Generally, the DED JPA is best used by more advanced technicians who do not need step-by-step prompting.

Unenriched (UN) HJPA

Figure 2 shows a sample of an UN HJPA, which presents deductive and directive troubleshooting elements side-by-side. The directive element (Figure 2.a) is a decision tree. The steps of a testing procedure are contained in the hexagonal nodes. In each case, a good or bad test outcome determines the ensuing step. The directive element is not a fully procedurized JPA, as it assumes that the technician knows the locations of the test points, is familiar with the use of test equipment, and can determine good and bad outcomes. However, it does guide him through a troubleshooting strategy.

The inexperienced technician can perform troubleshooting immediately by following the directive portion of the hybrid. He is told that he can follow the step-by-step reasoning behind the troubleshooting procedure by studying the accompanying deductive element (Figure 2.b) during a troubleshooting task. As he gains experience, he should be able to abandon the directive element and rely exclusively on the deductive element. Thereafter, when he needs help or wants to check his work, he can refer to the directive aid. This type of aid contains the minimum amount of information, in both the directive and deductive elements, needed by a technician to perform his job.

Task-specific/Internally-cued (TS/IC) EHJPA

Enrichment is information added to HJPAs to (1) point out to the less insightful users some learning opportunities inherent in the aid, and/or (2) introduce learning possibilities not normally present in performing a maintenance task (e.g., theory-based learning). When the enrichment concerns the task at hand, it is referred to as task-specific (TS). When it appears on the aid, it is referred to as internally-cued (IC). The TS/IC enrichment in Figure 3 includes the bracketed information following each test on the directive element (Figure 3.a) and the LRU name inside the blocks on the deductive element (Figure 3.b). The bracketed information on the directive element indicates which LRUs on the accompanying deductive element are cleared or suspected as a result of the test outcome. The purpose of this enrichment is to demonstrate and teach a troubleshooting method in which technicians rely on deductive aids.

System-specific/Basic-reference-cued (SS/BRC) EHJPA

The SS/BRC format is similar to the TS/IC. The difference is that the SS/BRC EHJPA includes paragraph references from the system technical manuals. These references, which are placed above or below the LRU block of the deductive element (Figure 4.b), provide general (basic) information about the specific system. The directive element (Figure 4.a) is the same as in the TS/IC.

Subjects

Twenty Navy personnel, having a mean age of 21.1 years and a mean experience in electronics of 6.2 months, served as subjects. They were classified according to two levels of electronics training--high and medium. High was defined as having completed "A" school in electronics and the organizational classes for the AN/AWG-10 missile control system simulator. Medium was defined as having completed "A" school only. Subjects were randomly assigned to one of four groups according to the type of aid used--DED, UN, TS/IC, and SS/BRC.

Equipment

All groups were tested at the Naval Air Station, Oceana, Virginia Beach, Virginia on the AN/AWG-10 missile control system simulator. The AN/AWG-10, a naval airborne weapon control system, is basically an analog system with some digital components in its computer.

Procedure

All groups were given a short introduction and orientation, a troubleshooting pretask using the DED format, a pretest on system knowledge, two troubleshooting tasks using one of the four JPA formats, a troubleshooting posttask using the DED format, a posttest on system knowledge, a questionnaire/interview on user acceptance, and, finally, a debriefing about the purpose of the experiment. These events are described below.

1. Introduction. Participants were shown the layout of the equipment and given a general explanation of the tasks they were to perform.

2. Pre- and Posttests on System Knowledge. The pre- and posttests on system knowledge were identical. The first part of the test determined the subjects' knowledge of system nomenclature by having them match an LRU name and its numerical designation. The second part measured the subjects' technical knowledge of particular components of the system used during the troubleshooting problems.

3. Troubleshooting Tasks and Type of Aid Used. Each subject in each group attempted to fault-isolate four equipment failures. Each task required the subject to use the aid, locate the test point, set up the test equipment, take a reading, compare the reading to the proper signal value, and judge whether the outcome was good or bad. This process was repeated until the subject had isolated the failed LRU or exceeded 40 minutes. Symptoms related to the failure of four different LRUs were used as the four problems. The problems were counterbalanced to avoid confusion between the effects of difficulty of task and learning effects. Table 1 illustrates the experimental design.

For task 1 (pretask), all subjects used the DED format. For tasks 2 and 3, subjects used the JPA format appropriate for their assigned group. For task 4 (the posttask), all groups again used the DED format. Subjects were assigned to the DED group used the DED format on all four tasks.

4. Questionnaire/Interview. A questionnaire (see appendix) was administered in two parts. Part I concerned subject demographic data, amount of electronics training, Navy goals, and the probability of the subject's pursuing a Navy career. Part II included 29 items on learning, enrichment, motivation, JPA attributes, and comparing JPAs to current technical materials. Subjects were to indicate, on a 5-point scale, how much they agreed with each statement. The rating scale for each question ranged from 1 to 5, where

Table 1

Experimental Design

Group	Subject	Training Level	Task Order	Troubleshooting Task Number and Type of Aid Used 1	2	3	4
DED	1	High	Order 1	DED	DED	DED	DED
	2	High	Order 2	DED	DED	DED	DED
	3	High	Order 1	DED	DED	DED	DED
	4	High	Order 2	DED	DED	DED	DED
	5	Medium	Order 1	DED	DED	DED	DED
	6	Medium	Order 2	DED	DED	DED	DED
UN	1	High	Order 1	DED	UN	UN	DED
	2	High	Order 2	DED	UN	UN	DED
	3	Medium	Order 1	DED	UN	UN	DED
	4	Medium	Order 2	DED	UN	UN	DED
TS/IC	1	High	Order 1	DED	TS/IC	TS/IC	DED
	2	High	Order 2	DED	TS/IC	TS/IC	DED
	3	High	Order 1	DED	TS/IC	TS/IC	DED
	4	High	Order 2	DED	TS/IC	TS/IC	DED
	5	Medium	Order 1	DED	TS/IC	TS/IC	DED
	6	Medium	Order 2	DED	TS/IC	TS/IC	DED
SS/BRC	1	High	Order 1	DED	SS/BRC	SS/BRC	DED
	2	High	Order 2	DED	SS/BRC	SS/BRC	DED
	3	Medium	Order 1	DED	SS/BRC	SS/BRC	DED
	4	High	Order 2	DED	SS/BRC	SS/BRC	DED

Legend: DED = deductive JPA.
UN = unenriched hybrid JPA.
TS/IC = task-specific/internally-cued enriched hybrid JPA.
SS/BRC = system-specific/basic-reference-cued enriched hybrid JPA.

1 = agree strongly, 2 = agree, 3 = disagree, 4 = disagree strongly, and 5 = don't know or not applicable. During an open-ended interview, subjects were able to express their opinions about any aspect of the aids not already covered in the questionnaire.

Analyses

Subjects in the DED group were used as a control group and compared to those in the UN, TS/IC, and SS/BPC groups on the following measures:

1. Fault-isolation time.
2. Solution rate (i.e., the proportion of problems solved correctly).
3. System knowledge.

The questionnaire was used to obtain qualitative data on user acceptance of the four EHJPA formats.

RESULTS

Fault-isolation Time

Table 2 shows, by group, the mean fault-isolation time (in minutes) for each of the four troubleshooting tasks. Only the mean fault-isolation time on the last task for the TS/IC group was significantly faster ($p < .05$) than the DED group ($t_{10} = 1.81$). There were no significant differences on the last task between the DED and SS/BRC group, the UN and DED group, or between any of the hybrid groups.

Table 2

Mean Fault-isolation Time by Group and Task Number

		Time (Minutes)			
Group	N	Task 1[a] (Pretask)	Task 2	Task 3	Task 4[a] (Posttask)
DED	6	33.1	22.3	23.1	25.1
UN	4	30.5	17.7	15.6	16.7
TS/IC	6	24.5	13.6	15.0	14.8
SS/BRC	4	18.1	22.5	17.8	18.7

[a]All groups used the DED format on tasks 1 and 4.

Solution Rate

Table 3 gives the solution rate results by group and task number. After an initial 67 percent, the DED group averaged 89 percent fault isolation rate on the last three tasks. For all hybrid groups, the solution rate was 100 percent after the initial task, in which the average solution rate was 69 percent. Note that on every problem where the hybrid was used (i.e., Tasks 2 and 3), the failure was correctly fault-isolated. When all hybrid subjects transitioned back to the deductive aid on Task 4, again every problem was correctly solved.

The difference between the solution rate in Task 4 and Task 1 for all groups was tested with the Wilcoxon Rank-Sum test. The difference was significant at the .05 level.

System Knowledge

Part I of the test of the enrichment information measured the subjects' knowledge of the system nomenclature by having them match the LRU name with its number. This type of enrichment was provided via the EHJPAs to the TS/IC and SS/BRC subjects during Tasks 2 and 3. The SS/BRC subjects had additional learning opportunities, as the LRU name/number was not only on their aid but also in the technical manual materials that were referenced from the aid.

Table 3

Solution Rate by Group and Task Number

Group	N	Solution Rate (Percent)			
		Task 1[a] (Pretask)	Task 2	Task 3	Task 4[a] (Posttask)
DED	6	67	100	83	83
UN	4	50	100	100	100
TS/IC	6	83	100	100	100
SS/BRC	4	75	100	100	100

[a]All groups used the DED format on these tasks.

Table 4 gives (1) the mean number of correct responses on the test that were given before and after the troubleshooting tasks, (2) the mean difference score, and (3) the percent increase for the groups. Since the DED and UN groups were never provided this enrichment, their sources were combined. There was a slight decrease in the combined DED and UN scores (guessing was allowed), the TS/IC had no change, and the SS/BRC group had a 38 percent increase.

Table 4

Nomenclature Test

Group	N	Mean Number Correct Responses		Mean Difference Score	Percent Change
		Pretest	Posttest		
DED+UN	10	4.3	4.1	-0.2	-5
TS/IC	5	5.2	5.2	0.0	0
SS/BRC	4	5.3	7.3	+2.0	+38

The Wilcoxon test indicated that there was no significant difference at the 0.10 level between the combined DED-UN and the TS/IC groups' mean difference scores. There was a significant difference at the 0.05 level between the SS/BRC and the combined DED-UN groups' mean difference scores and a significant difference at the 0.10 level between the TS/IC and the SS/BRC groups' mean difference scores.

Part II of the test measured the subjects' knowledge of the function of system components involved in the troubleshooting tasks. During troubleshooting, only the group with the SS/BRC had the opportunity to learn component functioning by referring to paragraphs in the technical manual that were pertinent to the components under test. This group was compared to the UN group, the only group using an HJPA without any

enrichment. As shown in Table 5, use of the technical manual material while troubleshooting resulted in a 47 percent increase in the SS/BRC group test score. The UN group subjects did not have the opportunity to read that enrichment and their scores were virtually unchanged. The Wilcoxon's Rank-Sum Test indicated at the 0.05 level that the SS/BRC difference score was significanly higher than the UN group's difference score.

Table 5

Component Function Test

Group	N	Mean Number Correct Responses Pretest	Mean Number Correct Responses Posttest	Mean Difference Score	Percent Change
UN	4	6.4	5.8	-0.6	-9
SS/BRC	4	4.8	7.0	+2.2	+47

User Acceptance

Of the hybrid aid users, 100 percent rated their aids as easier to use (question 1) and easier to understand (question 2) than technical manuals. The DED group rated their aids less favorably: Only 67 percent rated it easier to use and 57 percent rated it easier to understand than technical manuals. However, 100 percent of all subjects indicated that they could fault-isolate faster with these aids than with technical manuals (question 25).

Most subjects were ambivalent about using only the aids to perform their work (question 28), but all of them indicated that they would become better technicians more quickly by using the aids in conjunction with the technical manuals than by either alone (question 29).

In the interview phase, the subjects were shown all aid forms. Eighty-seven percent of those who were asked to rank-order their JPA preferences ranked the SS/BRC aid first, the TS/IC aid second, the UN aid third, and the DED aid fourth. The overwhelming majority of subjects preferred the SS/BRC aid because of the amount of information it contained and because the aid referenced the technical manual.

The deductive aid had extremely high acceptance among the instructor personnel who observed and helped to run the experiment. They particularly liked the ability of the aid to give the technician an overall picture--the functional layout rather than the traditional layout keyed to individual physical pieces of equipment.

DISCUSSION AND CONCLUSIONS

Although all the fault isolation times for the hybrid groups were faster than the times for the deductive control group, only the TS/IC group was significantly different than the DED group. When subjects used the TS/IC EHJPA, they solved the two test problems (Task 2 and Task 3) 58.7 percent faster than did the subjects using the DED aid. When both groups had to troubleshoot using only the DED aid, the TS/IC groups isolated the fault 69.6 percent faster, indicating that exposure to the EHJPA provided technicians

with the functional understanding and experiences necessary to troubleshoot using deductive information only. Using the deductive information only, subjects' performance did improve from Task 1 to Task 4, but the rate of improvement was less. For the DED group, the improvement rate was 31.9 percent, whereas the improvement rate for the TS/IC group was 65.5 percent. It can be assumed that the improvement for the DED would continue to improve until it asymptotes and performance is equivalent to the TS/IC group.

Solution rates for all hybrid groups in Tasks 2 and 3 were 100 percent. Ragardless of hybrid aid, subjects could solve all problems when only the deductive information was available: All the subjects who had used the hybrids for the previous problems were able to solve the Task 4 problem. Only 83 percent of the DED group could solve the Task 4 problem.

In acquiring system knowledge, only the SS/BRC group did better. This group could name components and describe component functions better after having used the EHJPA. This improvement may be the result of the subjects reading the additional technical material since there was no improvement for the TS/IC group on the nomenclature test. Except for the reference cues on the SS/BRC, both EHJPAs were the same.

The SS/BRC group did not show any improvement in fault isolation times from Task 1 to Task 4. It appears that subjects in that group were able to troubleshoot quite easily with the deductive element alone. This group, compared to the others, had the largest ratio of highly trained technicians, 3 to 1. Comparison of performance times for Task 1 shows that while neither the UN nor TS/IC groups were significantly different from the DED group, the SS/BRC group was. Thus, because of the close similarity between the TS/IC and SS/BRC aids, the performance of the TS/IC group provides a better evaluation of the EHJPA.

Opinion data showed high acceptance of the hybrids. The data indicate that 100 percent of those using hybrids said that they could fault-isolate faster with these new experimental aids than with the traditional, more deductive technical manual. Furthermore, 100 percent of those using hybrids said it was easier to use and understand than existing technical material. All subjects believed that they would become better technicians more quickly by using the aids in conjunction with the technical manuals than by using either alone. The SS/BRC was rated the most favorable of the hybrid aids by the inexperienced technician.

The findings suggest that an effective EHJPA has a directive element that allows accurate troubleshooting by inexperienced technicians. The deductive element allows the technician to comprehend the troubleshooting strategy embodied in the directive element. The addition of enrichment supplies the rationale for each step in the strategy. Over time, the technician can be expected to gain an understanding of the troubleshooting logic of the directive element and transition to using the deductive element alone. Then the technician will be able to extend his troubleshooting strategies to more complex sets of symptoms, for which there are no aids, and rely upon conventional functional flows and schematics to troubleshoot the problem.

RECOMMENDATION

Although the comparison of fault isolation times indicates better performance with the TS/IC EHJPA, the similarity of it to the SS/BRC, combined with the results of both the system knowledge test and user acceptance questionnaire/interview, suggest that the SS/BRC is the more effective EHJPA. Therefore, it is recommended that this EHJPA format be developed for the EPICS technician, who will be required to provide troubleshooting support at the intermediate level.

APPENDIX

QUESTIONNAIRE

QUESTIONNAIRE

Part I

1. Location ______________________ 2. Age _____ 3. Rate _______

4. Joined Navy in (month) ____________________ (Year) ______________.

5. Plan to leave Navy in (month) ______________ (Year) ______________.

6. Circle Navy schools attended:

School	Months in School
AFUN-P	____________
BE&E	____________
"A" School	____________
AFTA	____________
AWG-10 "C" School	____________
Other	
____________	____________
____________	____________

	Type of Work	Months
7. Electronic experience	________	_____
(Hobby, job, etc.)	________	_____

8. Your goals to be reached while in Navy:

   a. ____.

   b. ____.

9. Plan to make Navy a career? (circle one) Yes Undecided No

10. Probability of yourself having a Navy career. (circle one)

    0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Part II

AS = Agree strongly
AS = Agree
D = Disagree
DS = Disagree strongly
N = Don't know or not applicable

1. I found the materials in the exercise easier to use than what I now use.

AS A D DS N

2. Compared to other Navy technical manual materials I have seen, the materials used in the exercise were easier to understand.

AS A D DS N

3. I think I can teach mayself a lot about the AWG-10 system by using these new materials.

AS A D DS N

4. If I am doing electronic troubleshooting, I like to get the job done as quickly as possible.

AS A D DS N

5. I hope the Navy provides me with technical manuals like the ones used in this exercise.

AS A D DS N

6. The technical manual materials used were OK for someone just starting to do troubleshooting but would be too distracting for an experienced technician.

AS A D DS N

7. The materials I used in the exercise were too complicated.

AS A D DS N

8. I would like to learn as much about electronics as I can so that I can advance in rate as quickly as possible.

AS A D DS N

9. Having a step-by-step troubleshooting procedure on one page of a technical manual and a flow diagram on the facing page is a poor arrangement for helping the technician do the job.

AS A D DS N

10. I found that I was learning a lot about how the system works from using the materials in the exercise.

AS A D DS N

11. When I do a job such as electronic troubleshooting, I like to take the time to figure out how the system really works.

AS A D DS N

12. These new materials helped me learn more about the system as it was telling me what steps to do.

AS A D DS N

13. The enrichment helps you learn what this system does.

AS A D DS N

14. The enrichment was easy to understand.

AS A D DS N

15. The enrichment made the task more interesting.

AS A D DS N

16. Understanding the enrichment will make me a better technician in the long run.

AS A D DS N

17. If you could advance as quickly as your knowledge and skills develop, these new materials would be helpful in obtaining advancement.

AS A D DS N

18. I believe it to be a practical troubleshooting aid.

AS A D DS N

19. I like the idea of two different adjacent materials that vary in difficulty and detail.

AS A D DS N

20. These new materials appear to allow a person to rapidly learn his job.

AS A D DS N

21. Additional training is very important to me.

AS A D DS N

22. I think a person without formal schooling could troubleshoot most of the system using these JPAs if he had some PJE (OJT) from peers.

AS A D DS N

23. Even if I am not going to have a Navy career, it is important to me to advance as much as possible before separating from the Navy.

AS A D DS N

24. I believe other troubleshooters would like to have this type of JPA.

AS A D DS N

25. These new materials allow me to fault-isolate the problem faster than by using the techniocal manuals.

AS A D DS N

26. As an inexperienced technician, I can learn more from these aids than from technical manuals.

AS A D DS N

27. It is easier to understand the LRU relationships using these aids than with the technical manuals.

AS A D DS N

28 I would prefer to use these new materials rather than what I use now.

AS A D DS N

29. I can become a better AWG-10 technician more quickly by using both the new materials and the technical manuals than I can using the technical manuals alone.

AS A D DS N

30. The opportunity to get technical training can be a factor in a person's decision to join the Navy. How important was this factor in your own decision? (Express your answer as a percentage compared to all other factors.)

Technical training ________%

All other factors ________%

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